COMPUTATIONALLY EFFICIENT MORPHOLOGICAL AND PHOTOMETRIC MODELS OF THE LUNAR TERRAIN

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Introduction: There has been recent renewed interest in returning to the Moon and a proposal for the development of a Lunar Gateway as part of a larger effort for sustainable deep space exploration. In this context, surface telerobotic exploration/scouting missions are powerful enablers for researchers to learn more about the environment with minimal risk. Development of lunar virtual environment simulators and teleoperation interfaces for such remote exploration missions are critical from the aspect of astronaut training, mock-up missions, and operation planning. The interfaces should be specifically designed to minimize/offset cognitive load from the operator and yet empower them to explore the environment, carrying out scientific/operational objectives with minimal risk and resource wastage.

This paper will focus on development of a real time lunar environment simulator with specific focus on the morphological and photometric modelling of the lunar terrain. The simulator will generate virtual lunar terrain by synthetically enhancing the publicly available Digital Elevation Models to sub-centimeter resolution through fractal synthesis using parameters from the Apollo Lunar Surface Closeup Camera[1]. Subsequently, a computationally-efficient shader for the lunar regolith texture, albedo and back-scatter will be created using the classical Hapke model[2] and also utilize some of the more recent research in this field[3]. When coupled with a VR Head Mounted Display, real-time and photo-realistic lunar simulators like this will allow for a more realistic, immersive experience and provide intuitive feedback to the remote operator about the local environment of the rover. Specifically, they are useful in avoiding traverses closer to zero phase angles wherein back-scatter can cause temporary saturation/blinding of optical sensors and shadow hiding can result in lack of trackable features across image frames, both of which will cause disruption in visual navigation routines. By helping avoid such scenarios pro-actively, testbeds like these can cut down on operation and task planning/completion times.

This paper will be an extension of work done at Intelligent Systems Division, Ames Research Center[4] with focus on simplifying the reflectance and terrain models for fast rendering to realtime frame rates. The simulator will be developed in the Unity framework[5].

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References:

1. Helfenstein, Paul, and Michael K. Shepard. "Submillimeter-scale topography of the lunar regolith." *Icarus* 141.1 (1999): 107-131.

2. Hapke, Bruce. *Theory of reflectance and emittance spectroscopy*. Cambridge university press, 2012.

3. Wong, Un-Hong, et al. "Modeling the Reflectance of the Lunar Regolith by a New Method Combining Monte Carlo Ray Tracing and Hapke's Model with Application to Chang'E-1 IIM Data." *The Scientific World Journal* 2014 (2014).

4. Fong, Terry. "Lunar Robotics Update." (2018).

5. Technologies, U. (2019.1). *Unity - Manual: Unity Manual*. [online] Docs.unity3d.com. Available at: http://docs.unity3d.com/Manual/index.html